

Isopycnal Mixing in Ocean General Circulation Models and its Effect on the Simulation of Bomb Radiocarbon

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We report on the effect isopycnal mixing has on the simulation of bomb radiocarbon (bomb ^{14}C) in global ocean general circulation models (OGCMs). We performed OGCM simulations of the uptake by the ocean and the transport within the ocean of ^{14}C from atmospheric nuclear bomb tests. The models used were: (1) a modified version of the GFDL Modular Ocean Model (MOM) configured with simple horizontal subgrid scale mixing of tracers; (2) the same model using the Gent-McWilliams subgrid scale tracer transport parameterization, which includes isopycnal mixing; and (3) the Oberhuber's isopycnal coordinate model (OPYC), which also has isopycnal subgrid scale mixing. We used the same formulations for surface fluxes of heat and fresh water and the same sea ice model in all of our simulations to minimize differences in the results that might arise from differences in forcings. Additionally, all of the numerical grids were nearly the same.

Comparison of our model results to revised estimates of oceanic bomb ^{14}C from the GEOSECS observations and to Levitus mean annual temperature observations shows that our results are sensitive to the models' treatment of subgrid scale mixing of tracers. Because we could have matched either the observed mean vertical profile of ^{14}C or temperature alone by adjusting model parameters, we chose instead to judge the realism of the modeled vertical transport by how well we could simulate the mean vertical profiles of both ^{14}C and temperature with one set of parameter values. Judged by this standard, OPYC did a better job than did our baseline configuration of MOM, which we attribute mostly to the unrealistic treatment of subgrid scale mixing of tracers in this simulation. We illustrate this by showing that the use of the Gent and McWilliams (1990) tracer transport parameterization results in a greatly improved vertical temperature profile and almost no change in the bomb ^{14}C distribution, compared to our baseline MOM simulation.

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